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Harper, Jr.

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(54) **CONTACT FOR ELECTRICAL CONNECTOR**

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(52) **U.S. Cl.** **439/66**; 439/83; 439/874
(58) **Field of Search** 439/62, 83, 874, 439/876, 866, 867, 868

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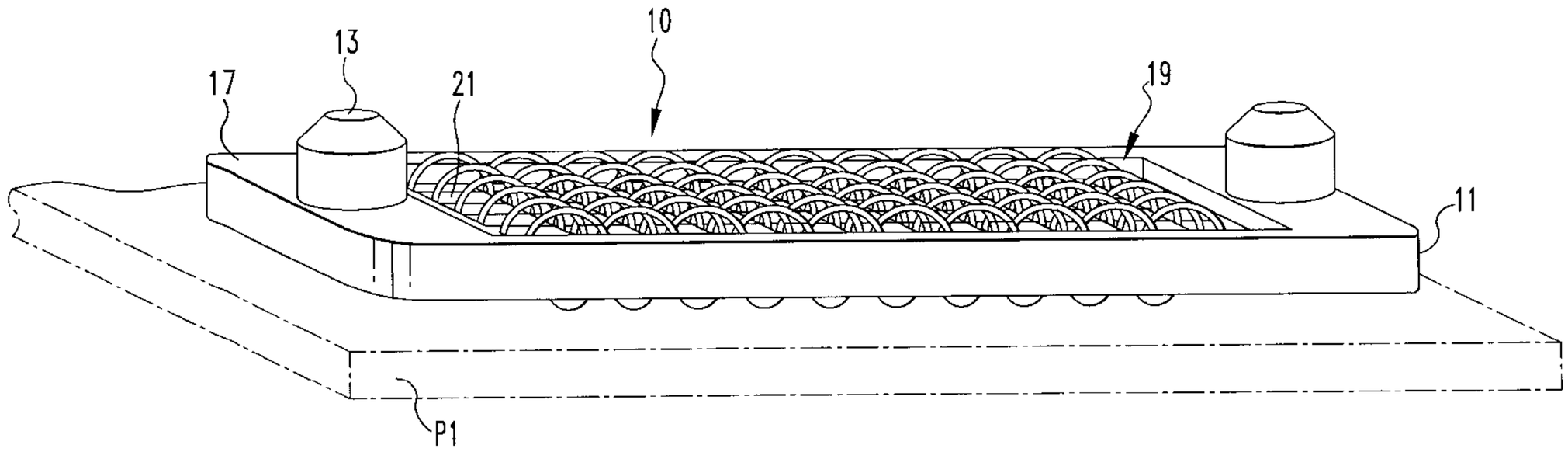
(57) **ABSTRACT**

A contact for use in an electrical connector that interconnects a first circuit substrate and a second circuit substrate. The contact can have an intermediate portion; a mounting portion extending from the intermediate portion for securing the contact to the first circuit substrate; and a mating portion extending from the intermediate portion and adapted to provide a non-linear wiping action to the second circuit substrate upon deflection of the mating portion by the second circuit substrate. The contact may be formed from a sheet of material and comprises: a mounting portion for mounting the connector to a first circuit substrate; and a mating portion for engaging a second circuit substrate. The mating portion has an edge that engages the second circuit substrate. The contact could be formed by: providing a sheet of conductive material; stamping a shape from said material, the shape including: an intermediate portion having a medial section and opposed ends; a mounting portion extending from the intermediate portion; and an arch-shaped mating portion extending from the intermediate portion and having an edge; and bending the opposed ends at an angle relative to said medial section. The edge of the mating portion is adapted to engage a circuit substrate.

23 Claims, 6 Drawing Sheets



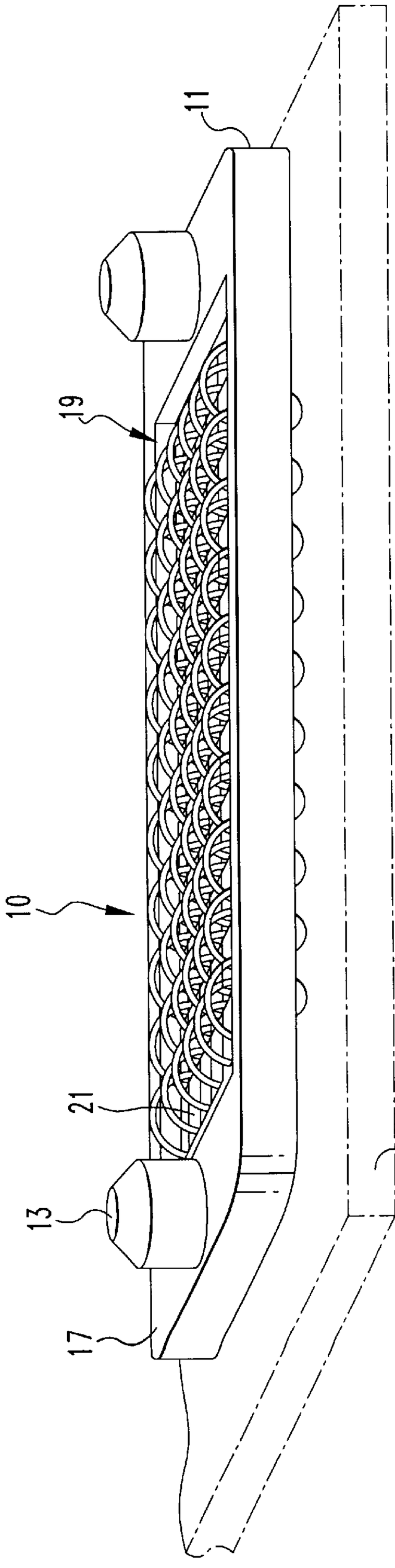


FIG.1

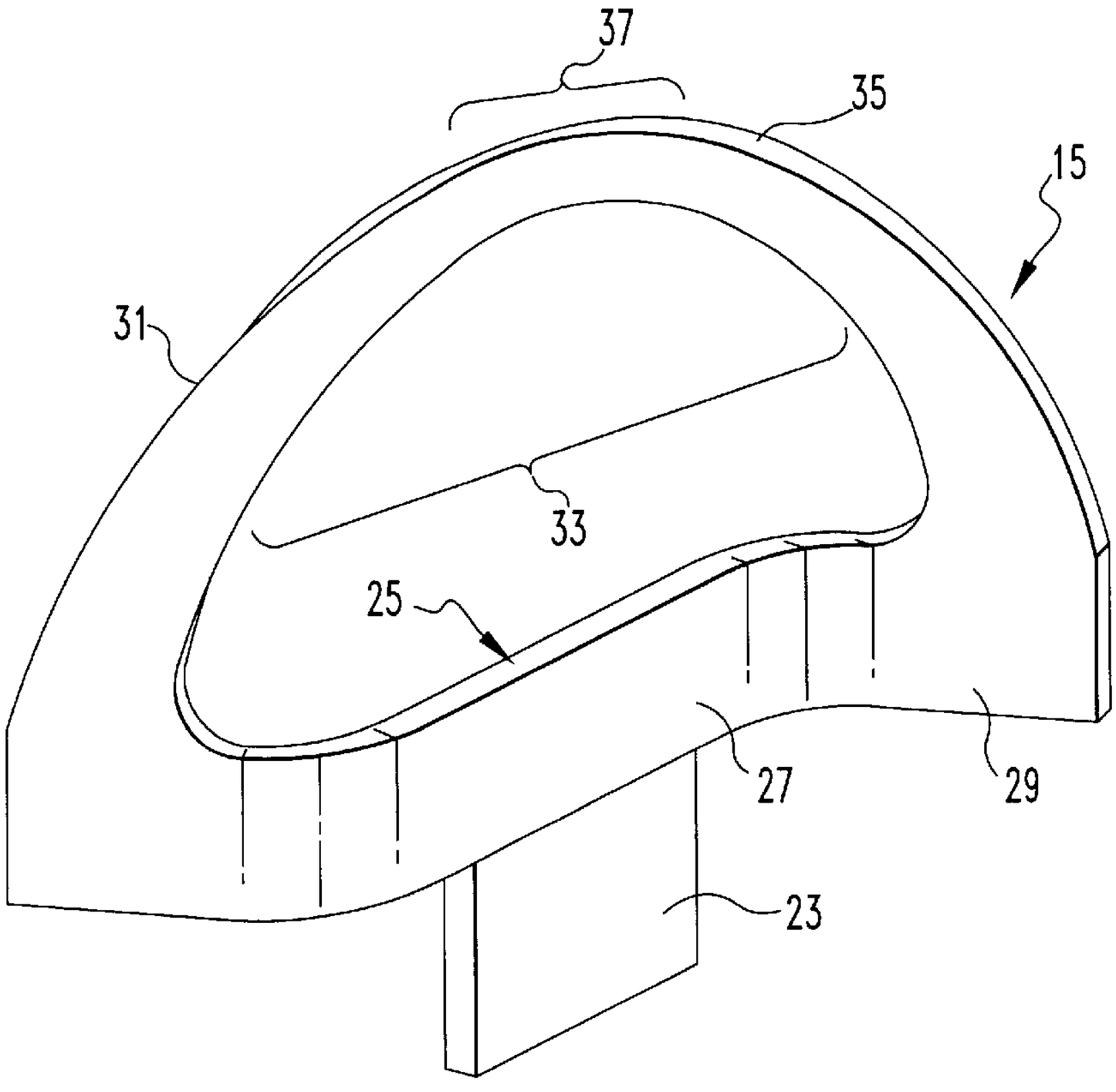


FIG.2a

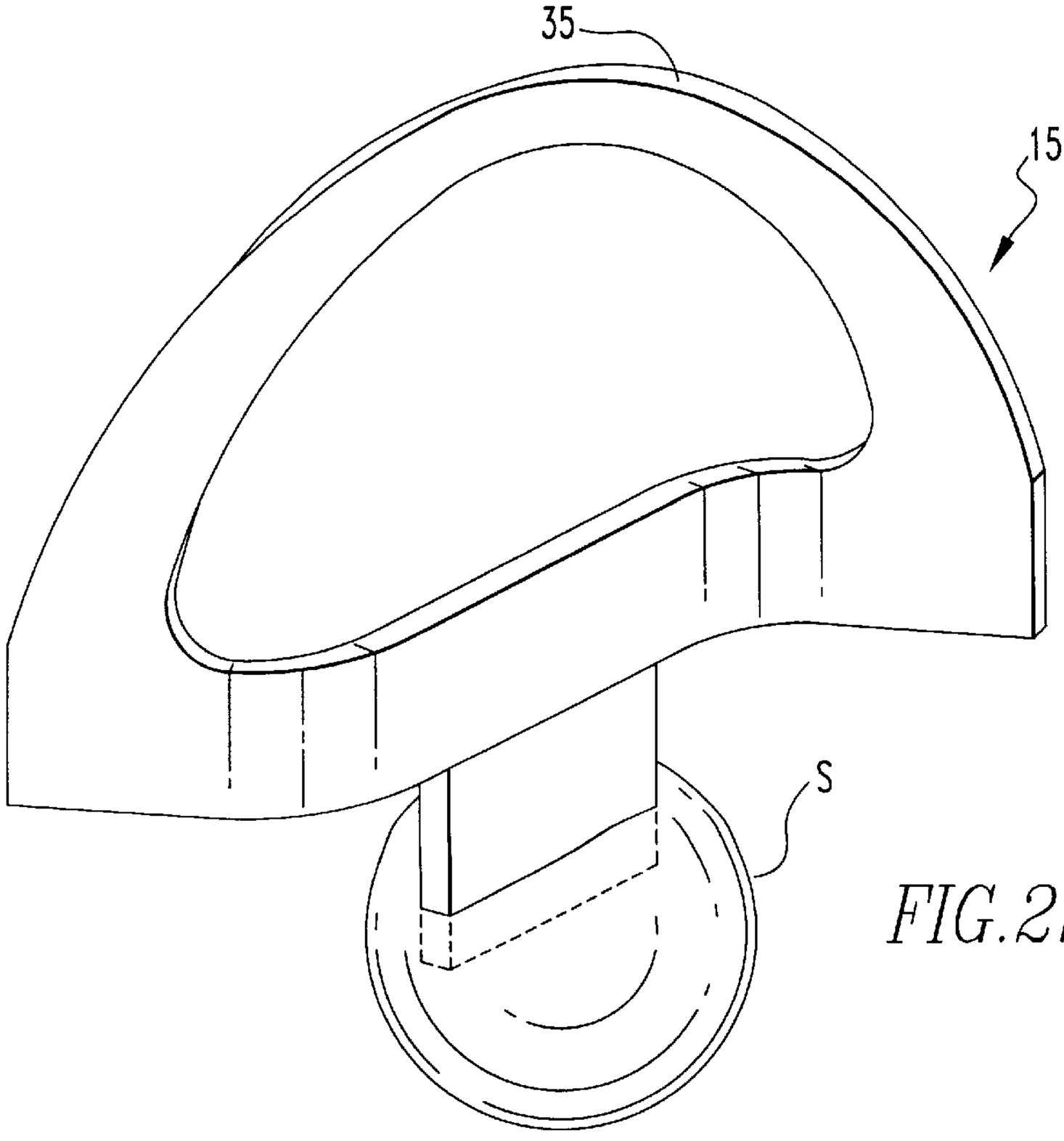


FIG.2b

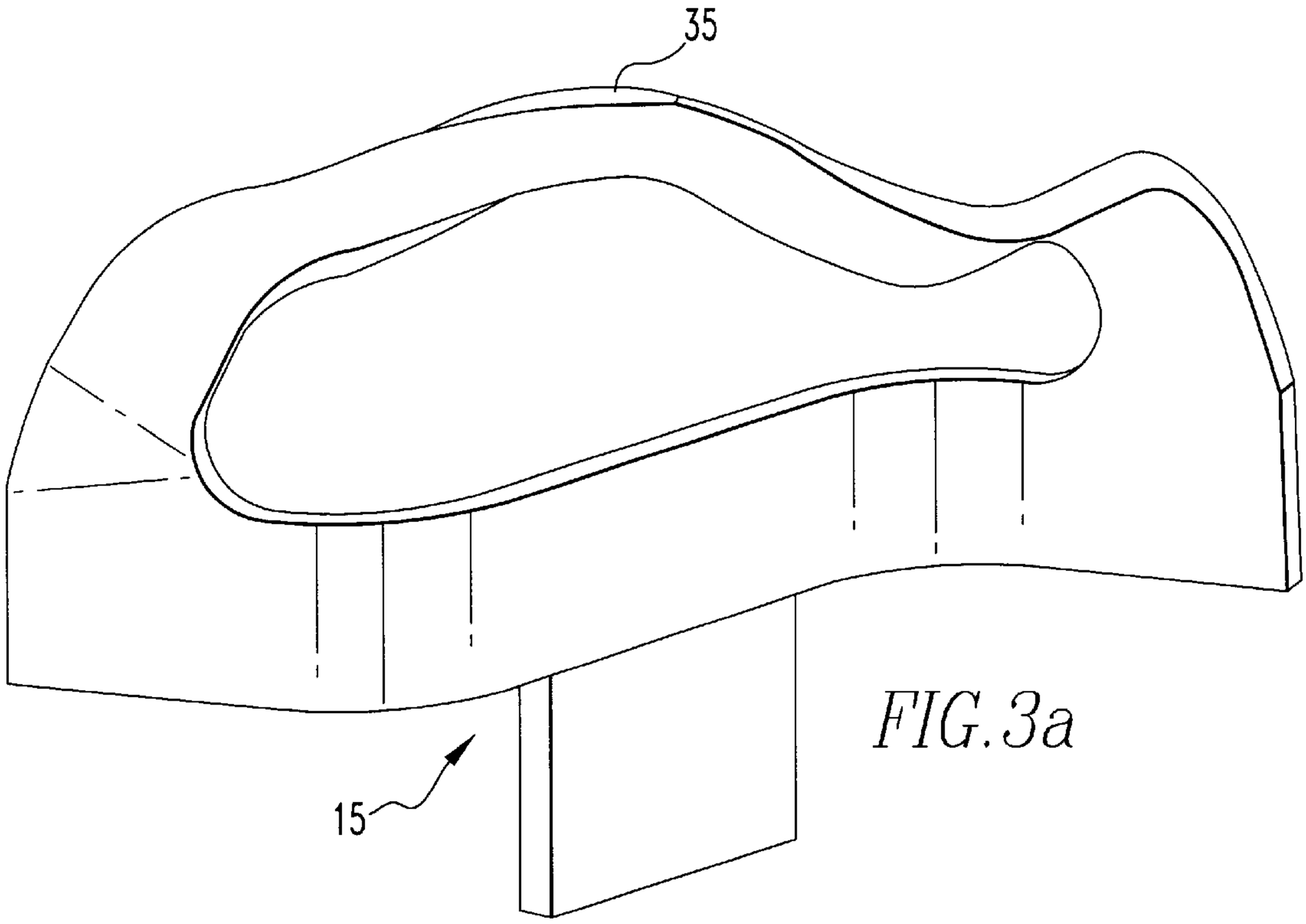


FIG.3a

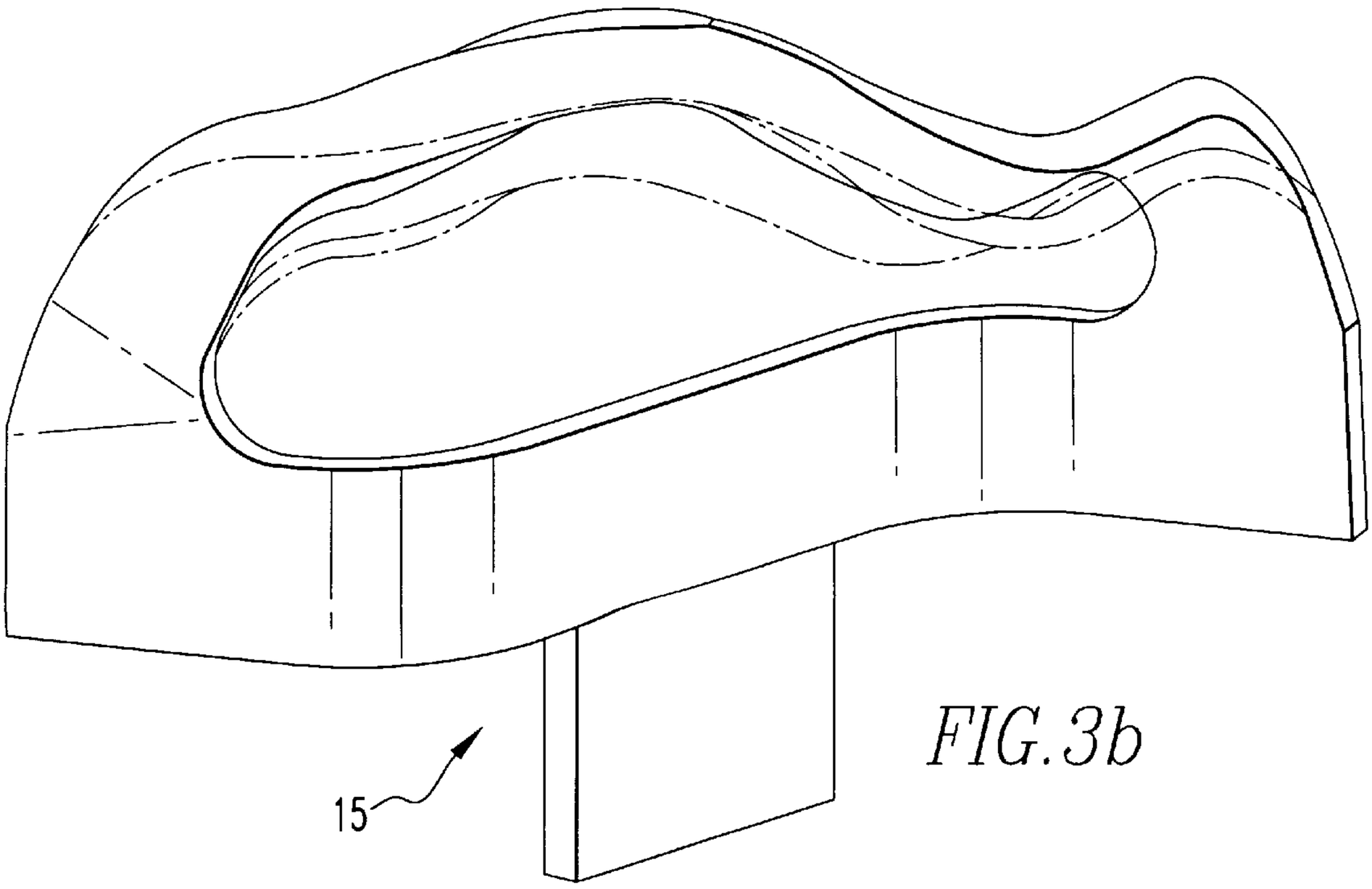


FIG.3b

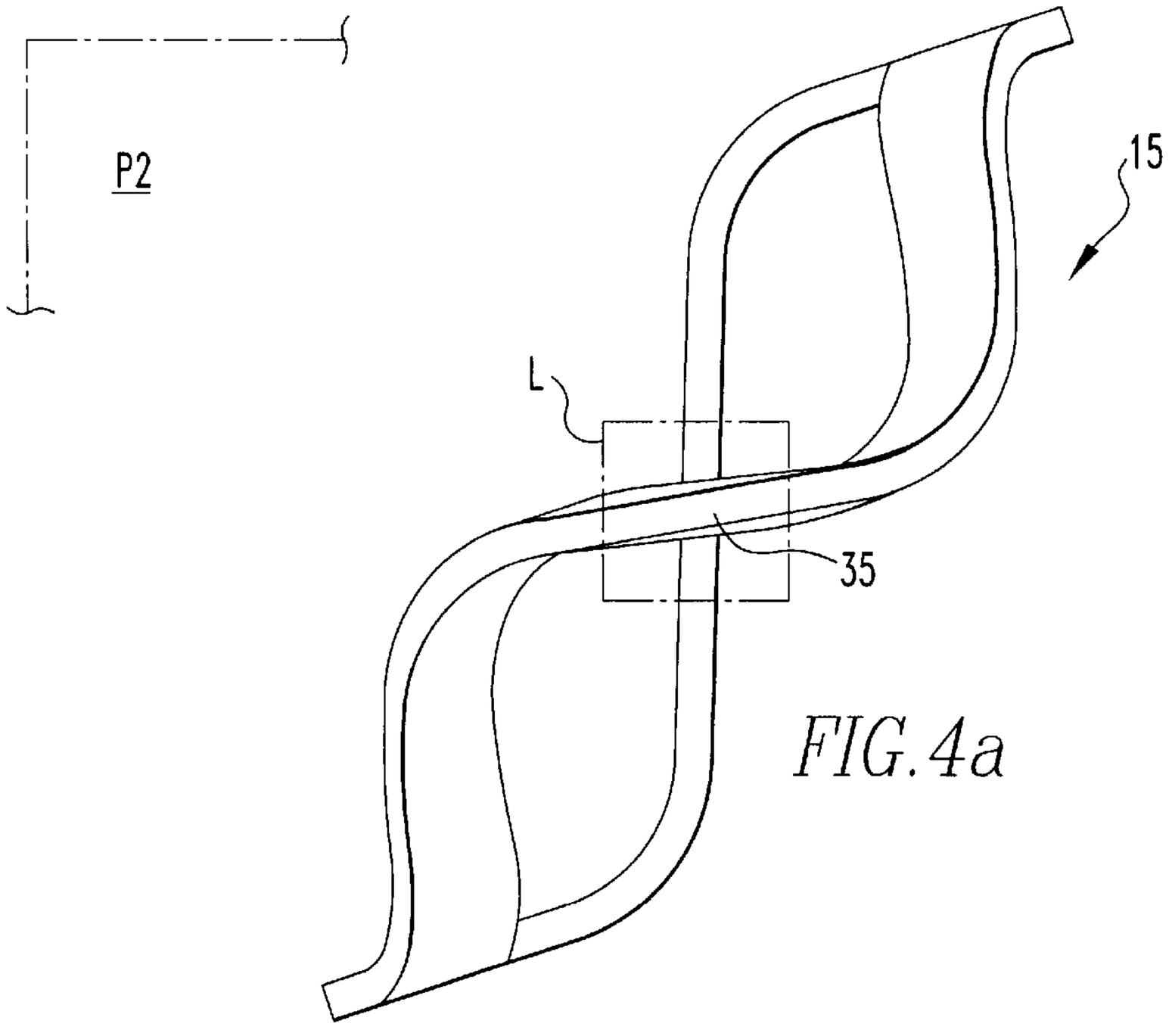


FIG. 4a

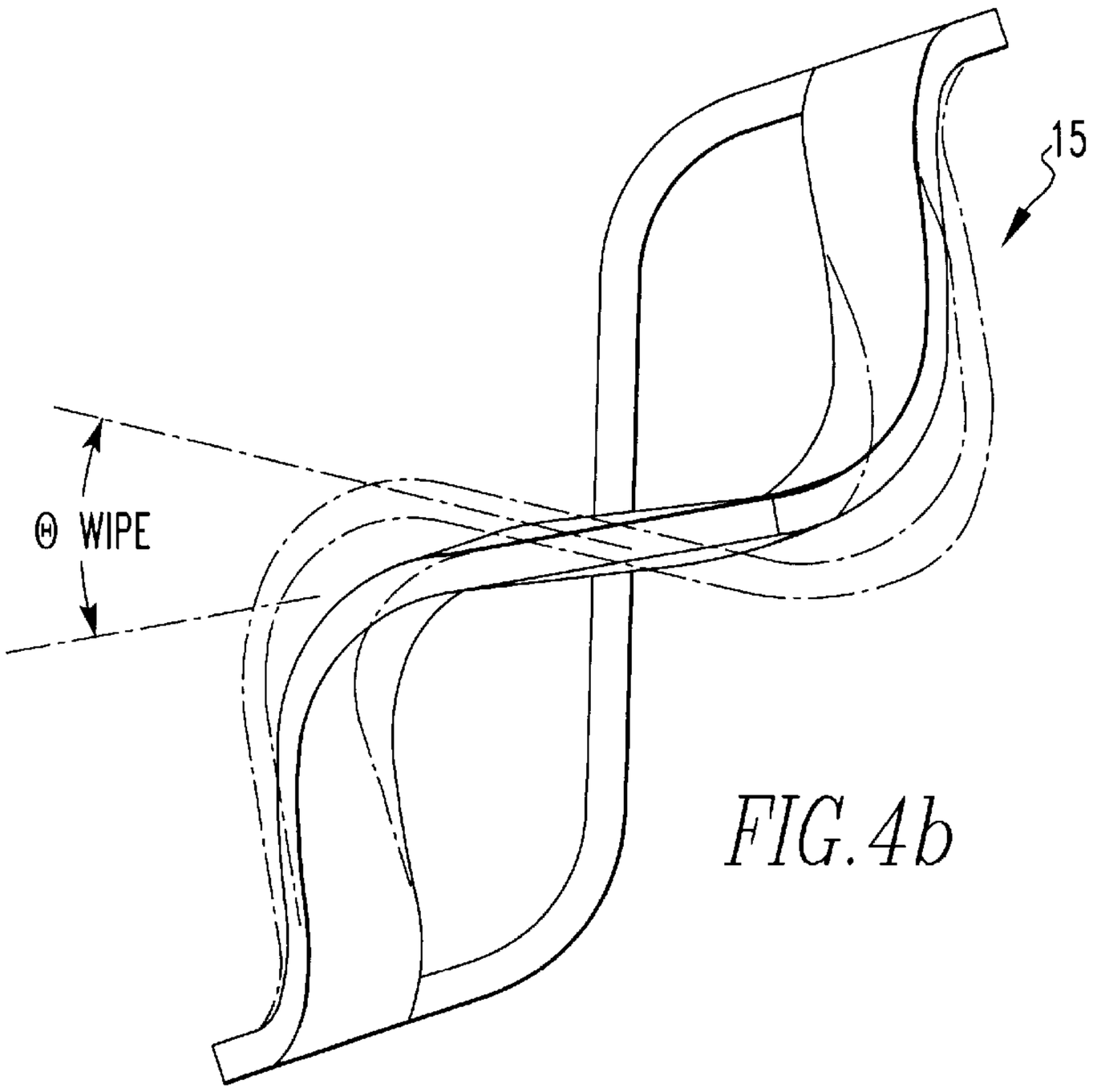


FIG. 4b

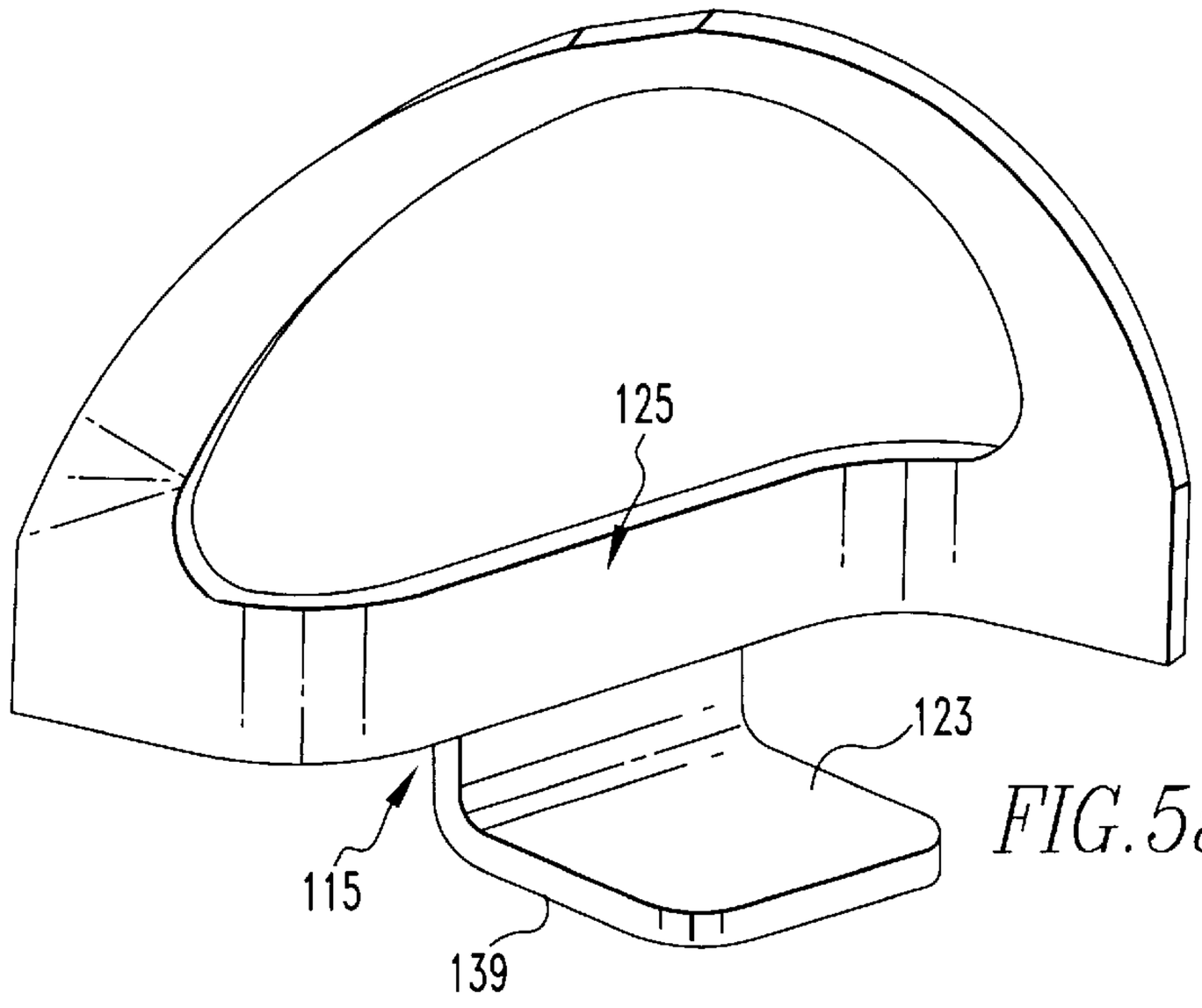


FIG.5a

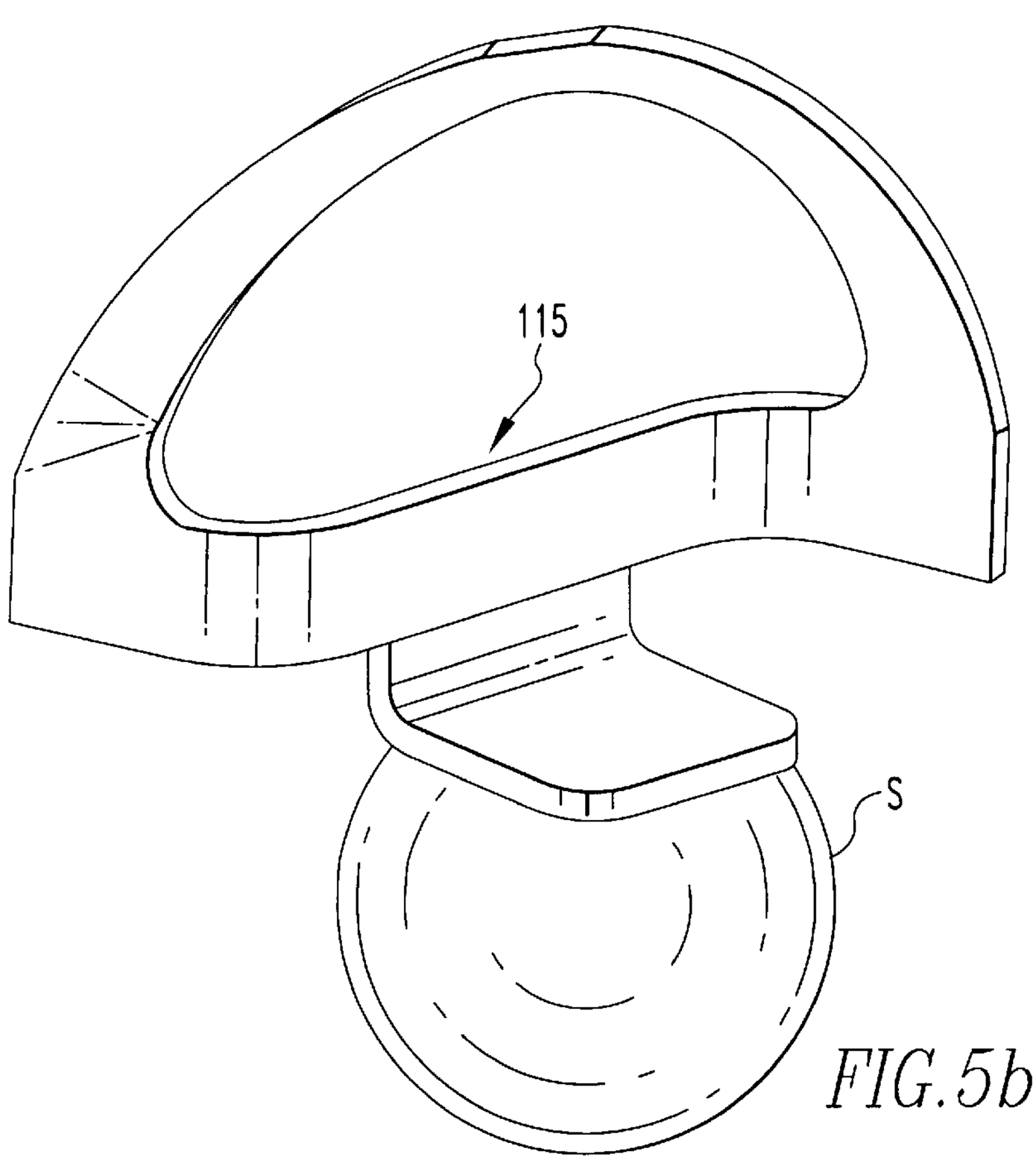


FIG.5b

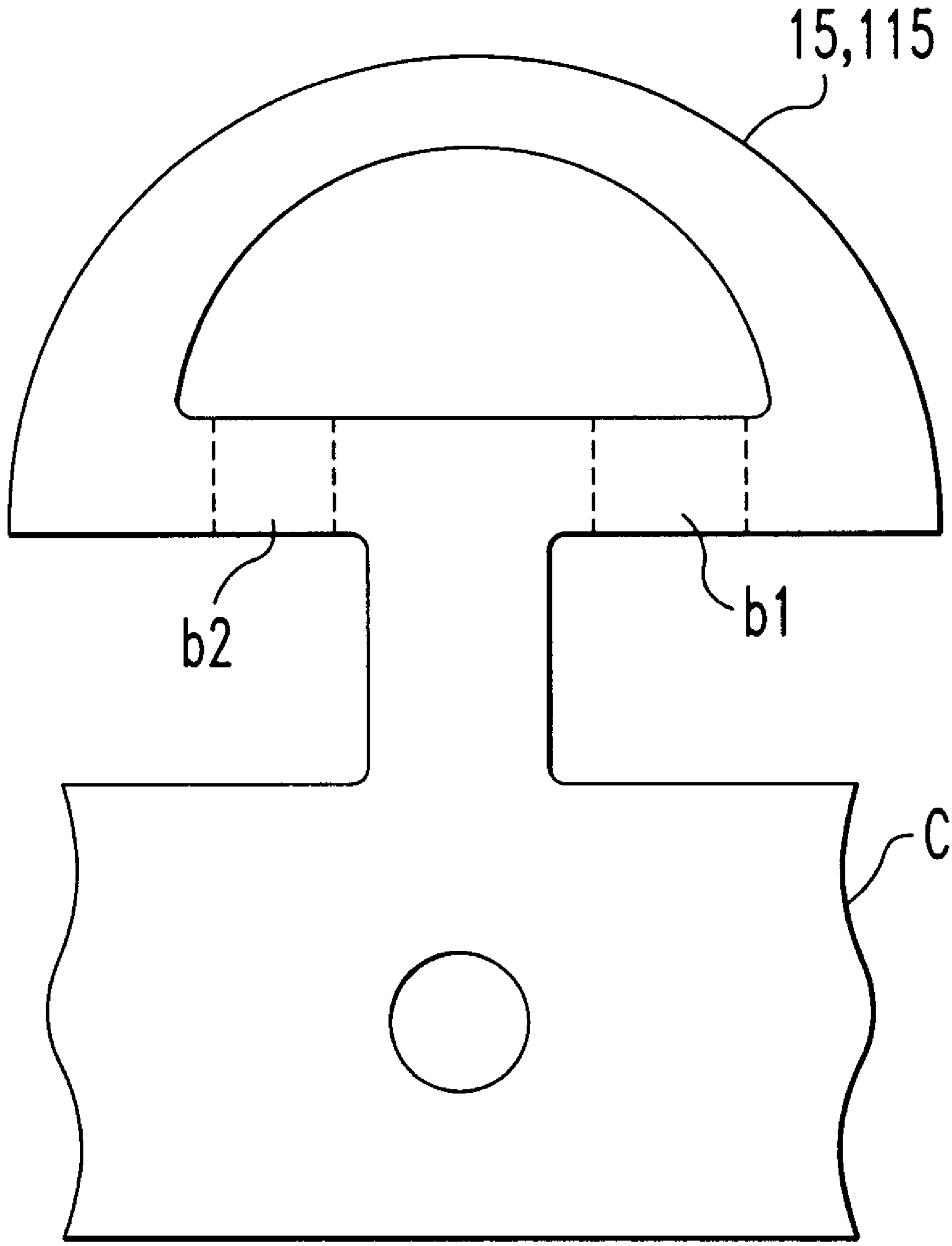


FIG.6

CONTACT FOR ELECTRICAL CONNECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a contact for an electrical connector. More specifically, the present invention relates to a compressive contact in an electrical connector that engages a pad on a circuit substrate.

2. Brief Description of Earlier Developments

Generally speaking, each new generation of an electronic product involves a miniaturization of the previous generation. Mobile telephones provide an excellent example. The size of each new generation of mobile telephones has consistently decreased from the previous generation of mobile telephones.

Miniaturization reduces the space available for the electronic components used in the product. While undoubtedly affecting electronic component design, the reduced size of the electronic components in the product also affects the design of the connectors used in the product. One design consideration as a result of miniaturization occurs in the X-Y plane of the connector. Miniaturization may require that the same number of contacts engage a smaller electronic component. In other words, the number of contacts per unit area of the connector, also known as contact density, must increase.

Another design consideration as a result of miniaturization occurs along the Z-axis of the connector. Miniaturization may limit the height of the connector. In a board-to-board interconnect, for example, product size may determine the maximum allowable spacing between boards. The interconnect must fit in the space between the boards.

Current electrical connector designs, while suitable for current generations of electronic products, may not be suitable for subsequent generations of electronic products. Thus, a need exists for electrical connectors capable of use in next generation electronic products.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved contact for use in an electrical connector.

It is a further object of the present invention to provide a contact having a non-linear wiping action.

It is a further object of the present invention to provide a compressive contact

It is a further object of the present invention to provide a low profile height electrical connector.

It is a further object of the present invention to provide an electrical connector that is inexpensive to manufacture.

It is a further object of the present invention to provide a surface mounted board-to-board electrical connector.

It is a further object of the present invention to provide a low profile BGA connector.

These and other objects of the present invention are achieved in one aspect of the present invention by a contact for use in an electrical connector that interconnects a first circuit substrate and a second circuit substrate. The contact has an intermediate portion; a mounting portion extending from the intermediate portion for securing the contact to the first circuit substrate; and a mating portion extending from the intermediate portion and adapted to provide a non-linear wiping action to the second circuit substrate upon deflection of the mating portion by the second circuit substrate.

These and other objects of the present invention are achieved in another aspect of the present invention by a

contact used in an electrical connector, formed from a sheet of material and comprising: a mounting portion for mounting the connector to a first circuit substrate; and a mating portion for engaging a second circuit substrate. The mating portion has an edge that engages the second circuit substrate.

These and other objects of the present invention are achieved in another aspect of the present invention by an electrical connector that interconnects a first circuit substrate and a second circuit substrate. The connector comprises: an insulative housing; and a contact. The contact has a intermediate portion located in the housing; a mounting portion extending from the intermediate portion for securing the connector to the first circuit substrate; and a mating portion extending from the intermediate portion and adapted to provide an arcuate wiping action to the second circuit substrate upon deflection of the mating portion by the second circuit substrate.

These and other objects of the present invention are achieved in another aspect of the present invention by a method of making a contact, comprising the steps of: providing a sheet of conductive material; stamping a shape from the material, the shape including: an intermediate portion having a medial section and opposed ends; a mounting portion extending from the intermediate portion; and an arch-shaped mating portion extending from the intermediate portion and having an edge; and bending the opposed ends at an angle relative to the medial section. The edge of the mating portion is adapted to engage a circuit substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

Other uses and advantages of the present invention will become apparent to those skilled in the art upon reference to the specification and the drawings, in which:

FIG. **1** is a perspective view of a connector utilizing a contact of the present invention;

FIG. **2***a* is a perspective view of one alternative embodiment of a contact of the present invention;

FIG. **2***b* is a perspective view of the contact in FIG. **2***a* associated with a solder ball;

FIG. **3***a* is a perspective view of the contact in FIG. **2***a* in an unloaded, or non-deformed, condition;

FIG. **3***b* is a perspective view of the contact in FIG. **3***a* in an unloaded condition (using solid lines) and a loaded, or deformed, condition (using phantom lines);

FIG. **4***a* is a top view of the contact in FIG. **2***a* in an unloaded, or non-deformed, condition;

FIG. **4***b* is a top view of the contact in FIG. **4***a* in an unloaded condition (using solid lines) and a loaded, or deformed, condition (using phantom lines);

FIG. **5***a* is a perspective view of another alternative embodiment of a contact of the present invention;

FIG. **5***b* is a perspective view of the contact of FIG. **5***a* associated with a solder ball; and

FIG. **6** is a side view of a contact of the present invention on a carrier strip prior to the forming process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention connects two electronic componets such as two circuit substrates. FIGS. **1**, **2***a*, **2***b*, **3***a*, **3***b*, **4***a*, **4***b* and **6** demonstrate a first alternative embodiment. FIGS. **1**, **4***a*, **4***b*, **5***a*, **5***b* and **6** demonstrate a second alternative embodiment. Each embodiment will be described individually below.

As seen in FIG. **1**, an electrical connector **10** mounts to a first circuit substrate, such as a printed circuit board (PCB) P1. PCB P1 can be made from a suitable material, such as FR4. PCB P1 includes conductive traces (not shown) thereon.

Connecter **10** has an insulative housing **11** made from a suitable dielectric material, such as liquid crystal polymer (LCP). Housing **11** can have a plurality of alignment post **13** extending therefrom. Alignment posts **13** engage corresponding apertures (not shown) in a second circuit substrate, such as PCB P2 (shown in phantom in FIG. **4***a*). Once alignment posts **13** enter the corresponding apertures during mating, contacts **15** are properly positioned relative to a pad, or land L, on PCB P2. Contacts **15** also secure, at their opposite end, to the traces on PCB P1.

Housing **11** has a mating face **17** against which PCB P2 abuts during mating. Suitable retention features (not shown) maintain PCBs P1, P2 together and PCB P2 against connector **10**. Typically, these retention features are separate from connector **10**. Thus, only a brief description is warranted. Alternatively, however, connector **10** could include, for example, latches or fasteners (not shown) to secure PCB P2 against connector **10**.

Housing **11** has a recessed area **19**. Within recessed area **19**, a plurality of apertures **21** extend through housing **11**. Contacts **15** reside within apertures **21**. Apertures **21** generally correspond to the shape of the portion of contacts **15** residing within housing **11**. When viewed in cross-section, the lower portion of aperture **21** adjacent PCB P1 generally conforms to the shape of the planar mounting portion of contact **15**. In addition, the upper portion of aperture **21** adjacent recessed area **19** generally conforms to the larger and arcuate shaped intermediate portion of contact **15**.

Preferably, contacts **15** are stitched into housing **11** using a known insertion machine. Since the intermediate and mating portions of contact **15** are larger than the mounting portion, insertion of contacts **15** preferably occurs from mating face **17** (i.e. the side of housing **11** having recessed area **19**) towards the side of housing **11** facing PCB P1. This serves to "lock" contacts **15** within housing **11** after contacts **15** secure to PCB P1. However, the present invention could also use an overmold process to form housing **11** around contacts **15**.

Contacts **15** are located within recessed area **19** to control the amount of deflection allowed during mating of connector **10** with PCB P2. Typically, recessed area **19** prevents permanent deformation of contacts **15** by PCB P2. This feature will be described in more detail below. Contacts are preferably made of a suitable conductive material, such as phosphor bronze or beryllium copper, with appropriate plating.

FIG. **2***a* provides a detailed view of the first alternative embodiment of contact **15** in an unloaded condition. Contact **15** has a mounting portion **23** used to mount connector **10** to PCB P1. FIG. **2***b* shows mounting portion **23** receiving a fusible element, such as a mass of solder S. Preferably, solder mass S is a solder ball. By utilizing solder mass S, connector **10** can surface mount to PCB P1 using reflow methods, including ball grid array (BGA) technology. International Publication number WO 98/15989 (International Application number PCT/US97/18066), herein incorporated by reference, describes methods of securing a solder ball to a contact and of securing a BGA connector to a substrate.

While FIG. **2***b* demonstrates one specific method of securing connector **10** to PCB P1, Applicant recognizes that the present invention could use other types of terminations, such as press-fit, surface mount and through hole.

Mounting portion **23** extends from an intermediate portion **25** of contact **15**. Intermediate portion **25** seats within housing **11**, specifically residing in correspondingly shaped aperture **17**. Intermediate portion **25** can have a generally planar medial section **27** flanked by curved sections **29**. Curved sections **29** can extend generally transverse to medial section **27** and preferably extend from medial section **27** in opposite directions. As seen in FIG. **4***a*, intermediate portion **25** is generally S-shaped.

A mating portion **31** also extends from intermediate portion **25**. Preferably, mating portion **31** extends from an opposite end of intermediate portion **25** than mounting portion **23**. As seen in FIG. **2***a*, mating portion **31** has an arcuate shape and extends in an arched fashion between opposed curved sections **29**. Mating portion **31** has a twisted middle section **33**. Twisted middle section **33** allows a minor surface **35** of mating portion **31** to face PCB P2 and to make contact with land L. The arrangement of twisted middle section **33** provides a generally planar area **37** along minor surface **35** with which to support land L of PCB P2. Planar area **37** continues to abut land L of PCB P2 even during deflection of contact **15**.

The interaction between land L and minor surface **35** (when compared to a major surface of middle section **33**) provides a more rigid support to PCB P2. The orientation helps contact **10** provide a suitable normal force to PCB P2.

Twisted middle section **33** also assists in the deflection of mating portion **31** by PCB P2 during mating. FIGS. **3**a and **4**a display contact **15** at rest, prior to engaging land L of PCB **2**. Minor surface **35** of contact **15** will engage receive land L of PCB P2 as PCB P2 approaches PCB P1. As land L bears against minor surface **35**, contact **15** begins to deflect.

FIGS. **3***b* and **4***b* display contact **15** in a loaded, or deflected, condition after PCB P2 seats against mating face **17** of housing **11** of connector **10**. As clearly shown in FIG. **3***b*, contact **15** compresses, or decreases in height. Even during compression, minor surface **35** of contact **15** remains against land L of PCB P2. In other words, planar area **37** maintains the same longitudinal orientation relative to land L of PCB P2 during continued compression of contact **15**. Compression of contact **15**, however, deflects the portions of mating portion **31** adjacent curved sections **29**. The resiliency of mating portion **31** provides a suitable normal force against PCB P2.

In addition to providing a suitable normal force, mating portion **31** also provides a suitable wiping action against land L of PCB P2. Mating portion **31** provides a complex wiping action to land L of PCB P2 during deflection. Preferably, minor surface **35** provides a wiping action that is, at least in part, non-linear. As seen in FIG. **4***b*, minor surface **35** preferably rotates relative to land L of PCB P2. Stated differently, mating portion **31** torsionally wipes land L of PCB P2 through an angle Θ_{wipe}. Preferably, mating portion **31** torsionally wipes land L of PCB P2 through an angle of between approximately 5 to 15°.

The amount of compression of contact **15** by PCB P2 determines the amount of angular wipe produced by mating portion **31**. As discussed earlier, recessed area **19** helps control the amount of compression of contacts **15**. Preferably, contacts **15** are compressed without deformation. Avoiding deformation maintains the resiliency of contacts **15**. The distance that contacts **15** extend above mating face **17** is the amount of compression allowed by connector **10**. Clearly, therefore, the extent of recessed area **19** determines the amount of deflection of contacts **15** by PCB P2.

FIG. **5***a* and **5***b* provide the second alternative embodiment of the present invention. Aside from one feature,

contact **115** is generally identical to contact **15** in FIGS. **2***a* and **2***b*. In order to avoid repetition, only the differences between contact **115** and contact **15** will be discussed. Rather than extending generally parallel as in the first alternative embodiment, mounting portion **123** extends at an angle from intermediate portion **125**. Preferably, mounting portion **123** extends transversely to intermediate portion **125**. FIG. **5***a* shows mounting portion **123** extending generally perpendicular to intermediate portion **125**. Preferably, bending of mounting portion **123** occurs after insertion of contact **115** into the connector housing. However, contact **115** could have a pre-bent mounting portion **123**.

Mounting portion **123** has a side surface **139** that faces PCB P1. As shown in FIG. **5***b*, a fusible element S secures to side surface **139**. As with the first alternative embodiment, fusible element S could be a mass of solder S. However, Applicant recognizes that the present invention could use other types of terminations.

In the preferred embodiment, contacts **15**, **115** are stamped and formed. The stamping and forming operation forms contacts **15**, **115** from a carrier strip C using known techniques. The forming step bends contacts **15**, **115** at locations b**1**, b**2**. Bends at locations b**1**, b**2** provide the arcuate shape to intermediate portion **25**.

As discussed above, minor surfaces **35** of contacts **15**, **115** engage lands L of PCB P**2**. During conventional stamping and forming, the minor surfaces **35** and the edges between minor surfaces and the major surfaces may be sharp or uneven. Preferably, therefore, the present invention performs a step in addition to the aforementioned stamping and forming. The additional step treats minor surfaces **35** and/or the edges between minor surfaces **35** and the major surfaces. As one example, minor surfaces **35** could be shaved. The conventional shaving process removes sharp edges or burrs created during stamping. Other treatments, such as coining or filing, could be used. This treatment step provides a smooth interface between contacts **15** and lands L on PCB P**2**.

Once contact **15**, **115** seats within aperture **17** in housing **11**, the interaction between intermediate portion **25** and aperture **17** prevents any torsional stresses that occur during mating from acting on the solder joint between mounting portion **23** and PCB P**2**. This helps ensure the quality of the solder joint through repeated mating cycles.

The present invention reduces the amount of space required by a connector located between two adjacent PCBs. In particular, the present invention demands less space between PCBs since the present invention utilizes only one connector housing. Conventional mezzanine connectors use two mateable housings.

While the present invention has been described in connection with the preferred embodiments of the various figures, it is to be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiment for performing the same function of the present invention without deviating therefrom. Therefore, the present invention should not be limited to any single embodiment, but rather construed in breadth and scope in accordance with the recitation of the appended claims.

What is claimed is:

1. A contact usable in an electrical connector interconnecting a first electronic component and a second electronic component, comprising:

an intermediate portion;

a mounting portion extending from said intermediate portion for securing the contact to the first electronic component; and

a mating portion extending from said intermediate portion and adapted to provide a wiping action to the second electronic component, the mating portion having two opposite spaced ends separately connected to the intermediate portion, the wiping action comprising a non-linear wipe path on a surface of the second electronic component upon deflection of said mating portion by the second electronic component.

2. The contact as recited in claim **1**, wherein said intermediate portion has an arcuate shape.

3. The contact as recited in claim **1**, wherein said intermediate portion comprises a medial portion generally residing in a plane and flanked by arcuate sections.

4. The contact as recited in claim **3**, wherein said arcuate sections extend in opposite directions from said plane of said medial portion.

5. The contact as recited in claim **1**, wherein said mating portion is a compressible member.

6. The contact as recited in claim **5**, wherein said mating portion has an arcuate shape.

7. The contact as recited in claim **6**, wherein said mating portion includes a twisted section.

8. The contact as recited in claim **1**, wherein said mounting portion extends transversely to said intermediate portion.

9. The contact as recited in claim **1**, wherein said mating portion extends generally transverse to said intermediate portion.

10. The contact as recited in claim **1**, wherein said non-linear wiping action is rotational.

11. The contact as recited in claim **1**, wherein a minor surface of said mating portion engages the second substrate.

12. A contact, used in an electrical connector, formed from a sheet of material and comprising:

a mounting portion for mounting the connector to a first electronic component; and

a mating portion for engaging a second electronic component, said mating portion having a narrow side edge substantially formed by a thickness of the sheet of material that engages the second electronic component, wherein said mating portion is an arch with a top of the arch being located for contacting the second electronic component.

13. The contact as recited in claim **12**, wherein said arch has a twisted section.

14. An electrical connector interconnecting a first electronic component and a second electronic component, comprising:

an insulative housing; and

a contact, comprising:

an intermediate portion located in said housing;

a mounting portion extending from said intermediate portion for securing the connector to the first electronic component; and

a mating portion extending from said intermediate portion and adapted to provide a wiping action to the second electronic component upon deflection of said mating portion by the second electronic component, wherein the mating portion comprises two spaced ends connected to the intermediate portion, and wherein a wipe path along a surface of the second electronic component has an arced shape.

15. The electrical connector as recited in claim **14**, further comprising a fusible element secured to said mounting portion for surface mounting the connector to the first electronic component.

16. The electrical connector as recited in claim **15**, wherein said fusible element is a solder ball fused to said

mounting portion for subsequent surface mounting to the first electronic component.

17. The electrical connector as recited in claim **14**, wherein said housing includes structure to prevent movement of said contact within said housing during mating.

18. The electrical connector as recited in claim **14**, wherein said structure includes an aperture in said housing corresponding to a shape of said contact inserted therein.

19. The electrical connector as recited in claim **18**, wherein said housing has a mating surface facing the second electronic component, said mating surface having a recessed area, said aperture located within said recessed area.

20. An electrical contact for connecting two printed circuit members to each other, the electrical contact comprising:

a mounting portion for connecting the contact to a first one of the printed circuit members; and

a mating portion connected to the mounting portion, the mating portion being adapted to contact a second one of the printed circuit members and being sized and shaped to deflect towards the mounting portion when moved by the second printed circuit member, wherein the mating portion has two spaced ends and a contact area for contacting the second printed circuit member which is between the two spaced ends and located further away from the mounting portion than the two spaced ends, wherein the mating portion is sized and shaped to wipe a contact wipe path along the second printed circuit member as the mating portion is moved by the second printed circuit member, and wherein the contact wipe path has a general arced shape.

21. A contact as in claim **20** wherein the mating portion is sized and shaped to wipe two arced contact paths along the second printed circuit member.

22. A contact as in claim **21** wherein the two paths are substantially mirror images of each other.

23. A contact as in claim **20** wherein the mating portion is sized and shaped to twist at a point of contact with the second printed circuit member.

* * * * *